

Central and Eastern U.S. Winter Storm and Arctic Outbreak – January 5-7, 2014

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Meteorological Overview: The first week of 2014 was quite active across the U.S. with a major winter storm impacting much of the Middle Mississippi/Ohio Valleys and Great Lakes region. A widespread axis of 6-12” of snow fell from central Missouri northeastward through Illinois and Indiana and into Lower Michigan with isolated amounts nearing 18” across northern Indiana (Figure 1). Additional heavy accumulations fell downwind of the major Great Lakes as cyclonic flow and favorable lake trajectories set up over the region. In addition to the wintry precipitation, some of the coldest conditions in nearly 20 years affected the eastern two-thirds of the country with a plethora of record temperatures broken. The upper flow was meridional all the way up to the Arctic Circle and provided a direct path for cold advection toward the U.S. The arctic oscillation (AO) index was near -2 during this period which indicated a downstream blocking ridge over the high latitudes allowing this broad negative height anomaly to setup over the nation. An average temperature of 17.9°F on 6 January across the contiguous U.S. was the coldest since 12-13 January, 1997 and ranked the 40th coldest day on record since 1900 (Figure 2). Such readings were achieved without much snowpack or optimal radiational cooling effects given vast cloud cover and gusty winds. Rather it was driven by strong cold advection as evidenced by the sub -18°F 850-hPa temperatures across much of the north-central U.S. on 6 January. As noted by the sharp pressure gradient, windy conditions led to some dangerously low wind chills. During the event, wind chill readings plunged as low as the -60s Fahrenheit across the Northern High Plains. All and all, the arctic outbreak led to widespread impacts but was generally short-lived. The lobe of the polar vortex which crossed the Great Lakes quickly lifted northeastward into Quebec.

The multi-day snowfall event commenced by late morning on 4 January along a nearly stalled frontal zone stretching from northern Missouri up through the Upper Great Lakes. Snowfall was light given the air mass downstream was dry with dew points only in the 20s Fahrenheit. Eventually warm advection began to pick up ahead of a southern stream shortwave moving through southern Kansas on 5 January (12 UTC) (Figure 3) which helped further moisten the low-levels of the troposphere. The thermal gradient continued to strengthen across the Upper Great Lakes ahead of a deepening 850-hPa low which was moving from southern Missouri into northwestern Ohio between 12-00 UTC on 5-6 January. This sharpening temperature contrast led to a layer of 850-700-hPa frontogenesis stretching west and north of the 850-hPa low track where moderate to heavy snows began to fall. Conditional symmetric instability was noted within cross-sections as an axis of negative equivalent potential vorticity was found above the deep frontogenetic layer. At this time, a pair of upper jets coupled across Illinois and Indiana by 18 UTC on 5 January. Eventually the baroclinic zone became more progressive in nature once the 500-hPa lows phased across the Upper Great Lakes by 12 UTC on 6 January which quickly carried the precipitation axis eastward. Behind the front in the Central U.S., blowing snow and reduced visibilities became commonplace. Overall, the snow which fell consisted of variable snow-to-liquid ratios (SLRs) which ranged from roughly 11:1 to 17:1. The latter value was more commonplace within the deformation zone where surface temperatures plunged into the lower teens as heavy snow began to fall. During the height of the heavy snowfall, Chicago O’Hare saw wind chills below 0°F with visibilities dropping to less than two-tenths of a mile. In addition to the widespread snow, freezing rain fell early in the event on the morning of the 5 January with at least a quarter inch of ice reported across areas of the Mid-Atlantic. Southwesterly flow ahead of

the upper trough between 950-800-hPa allowed warm air to overrun a surface layer which had decoupled and remained in the upper 20s.

Impacts: The combination of heavy snowfall, ice, and bitterly cold temperatures led to quite a disruption to infrastructure and commerce. Accumulating ice caused a Delta Air Lines aircraft to skid off the runway and into a nearby snowbank at John F. Kennedy International Airport (JFK). Thousands of flights in the affected area were canceled due to the inclement weather including at Chicago O'Hare International Airport (ORD) where jet fuel and deicing fluids froze in the below 0°F conditions. In addition to aviation, train operations were severely hampered as cancellations and hours of delays became the norm. The historic cold snap also forced the closure of all public schools in Minnesota on 6 January for the first time in 17 years. Further, Ohio State University in Columbus, OH, which had not been completely shut down since 1978 was closed from 6-7 January. Unfortunately, this winter storm led to at least 3 fatalities, 2 of which were attributed to the frigid temperatures.

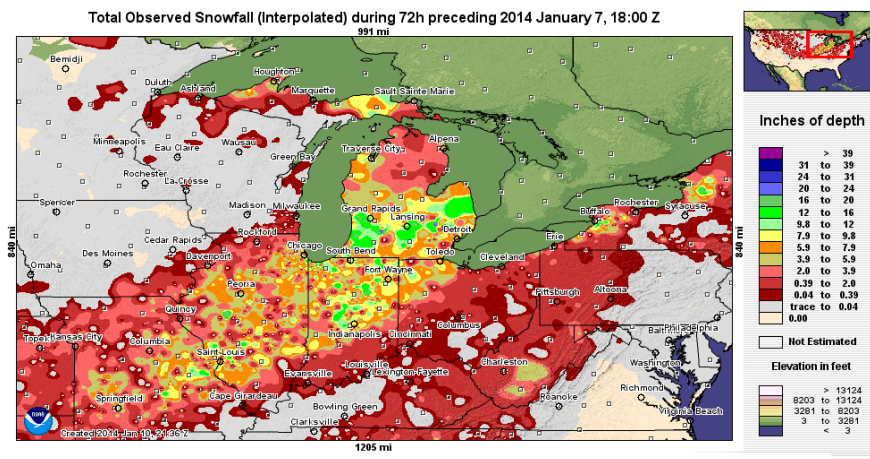


Figure 1: Total snowfall (inches) during the January 5-7 snowstorm (image from National Operational Hydrologic Remote Sensing Center)



Figure 2: Photograph of Lake Michigan during the height of the arctic intrusion (courtesy of International Business Times)

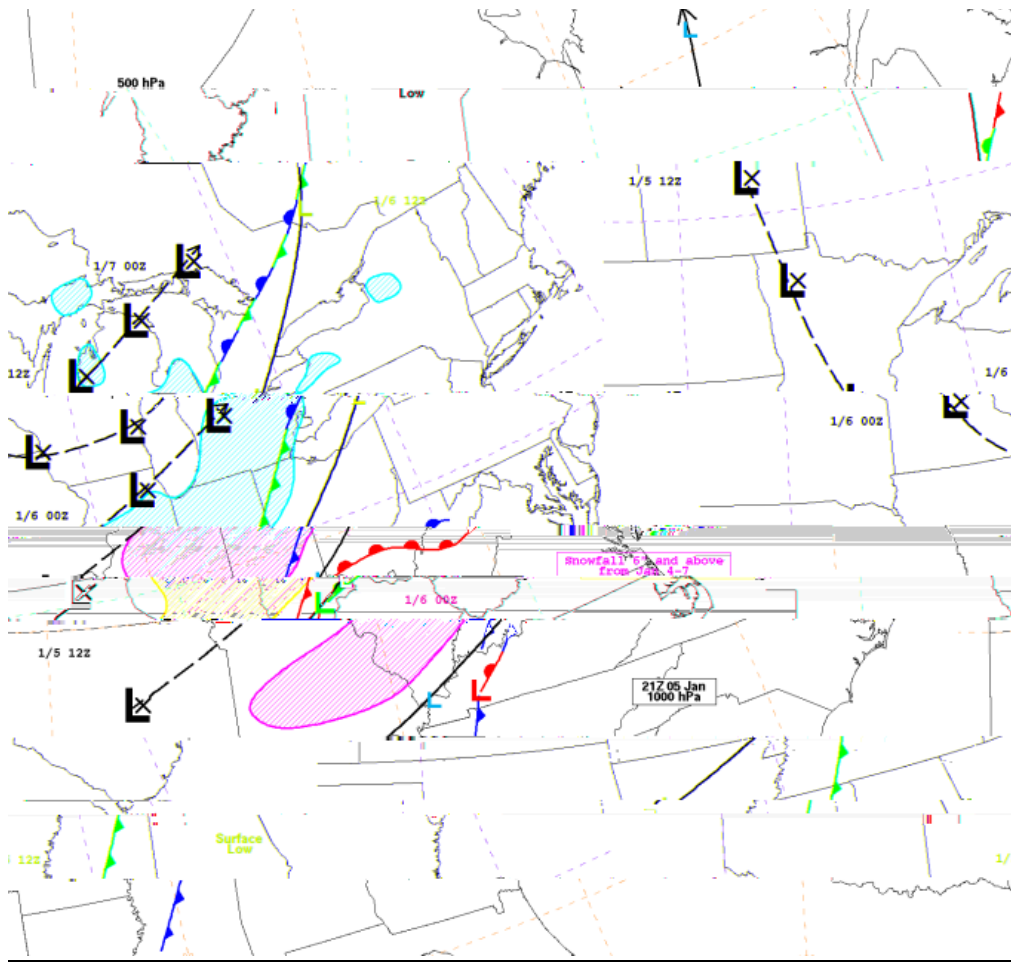


Figure 3: 500-hPa low track (black), surface low track (light blue), frontal analysis at 21 UTC on January 5, snowfall axis 6" and above (pink)